MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2021/2022

PTH0016 MODERN PHYSICS AND THERMODYNAMICS

(Foundation in Engineering)

5 OCTOBER 2022
9:00 A.M. – 11:00 A.M.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 7 pages, excluding the cover page.
2. Answer all questions.
3. Write your answers on answer sheets given.
4. Show all relevant steps to obtain maximum marks.

QUESTION 1 (15 MARKS)

a) Define Total Internal Reflection.

[1 mark]

b) **Figure Q1(b)** shows a parallel-sided of glass is formed by two prisms with same angle but different indices of refraction. The index of the first prism n_1 = 1.52 and that the second prism is n_2 = 1.77. If a ray of light is incident on the first prism as shown in the diagram, determine the angle that the emerging ray will make with the incident beam.

[5 marks]

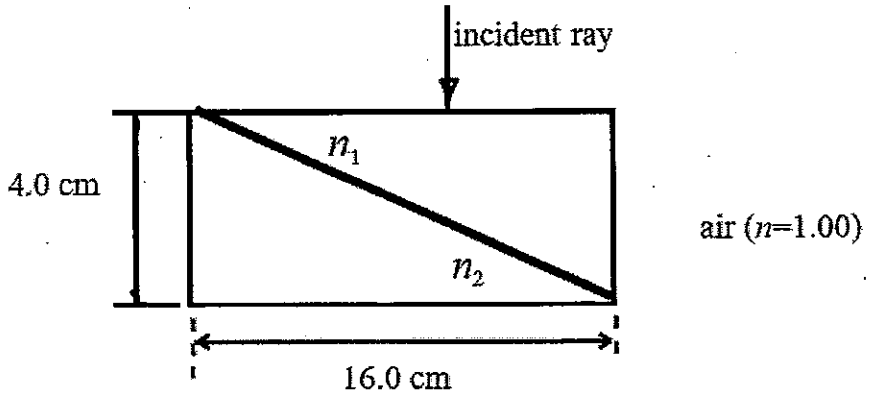


Figure Q1(b)

c) A 5.8 cm high candle is placed at a distance of 20.4 cm from a converging lens of focal length 7.0 cm.

i) Determine the location of the image.

[1.5 marks]

ii) Determine the lateral magnification.

[1.5 marks]

iii) Find the height of the image.

[1.5 marks]

iv) State whether the image lies in front of the lens or at the back of the lens.

[0.5 mark]

v) State whether the image is upright or inverted.

[0.5 mark]

d) Light of wavelength 550 nm incident on a pair of slits produces an interference pattern on a distant screen in which the separation between adjacent bright fringes at the centre of the pattern is 0.47 cm. A second light source, when incident on the same pair of slits, produces an interference pattern on the same screen with a separation of 0.58 cm between adjacent bright fringes at the centre of the pattern. Calculate the wavelength of the second source.

[3.5 marks]

Continued...

QUESTION 2 (10 MARKS)

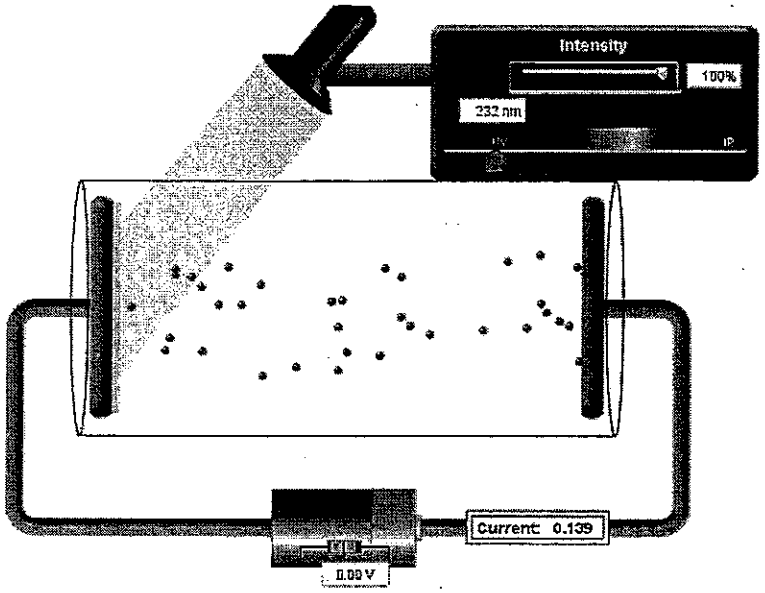


Figure Q2

a) Based on figure Q2, answer the following questions:

i) What is the purpose of this experiment?

[1 mark]

ii) If you increase the voltage of the battery to maximum voltage, what shall you observe the current flows ?

[1 mark]

iii) If you reverse the polarity of the battery to maximum voltage, what shall you observe the current flows ?

[1 mark]

iv) Sketch the graph of current I vs voltage of battery V , combine for part (ii) and (iii) into a single graph.

[1 mark]

v) It takes 4.2 eV to remove one electron from metal surface. When ultraviolet photons of a single frequency strike a metal, electrons with kinetic energies from zero to 2.6 eV are ejected. What is the energy of the incident photons in Joule and its wavelengths?

[2 marks]

b) When a hydrogen atom is bombarded, the atom is excited to its higher energy states. As it falls back to the lower energy levels, light is emitted.

i) What is the longest wavelength spectral line emitted by the hydrogen atom as it falls to the n = 1 state from higher energy states?

[2 marks]

ii) If there is incoming light with energy of 12.7 eV shine on the electron at n = 1 for same atom, which highest orbit the electron able to make the transition?

[2 marks]

Continued...

QUESTION 3 (10 MARKS)

a) Complete the following decay processes by filling in the blanks.

i) $^{231}_{90}\text{Th}^{*} \rightarrow {}^{231}_{90}\text{Th} + _____$

[0.5 mark]

ii) $^{210}_{84}\text{Po} \rightarrow {}^{206}_{82}\text{Pb} + _____$

[0.5 mark]

b) In many cases, tumor cancer is treated by implanting 60 to 100 small seeds of radioactive material into the tumor. The energy released from the decays kills the tumor. One isotope that is used (there are others) is palladium (^{103}Pd), with a half-life of 17 days. If a typical grain of the seeds contains 0.250 g of ^{103}Pd, calculate

i) the initial number of nuclei present.

[1.5 marks]

ii) the decay constant.

[1.5 marks]

ii) the initial activity rate in Bq.

[1.5 marks]

iii) the activity rate 68 days later in Bq.

[1.5 marks]

c) State the definitions of the following:

i) Disintegration of Energy.

[1 mark]

ii) Binding Energy.

[1 mark]

d) Complete the nuclear reactions below:

i) $^{239}_{94}\text{Pu} \rightarrow {}^{112}_{46}\text{Pd} + {}^{124}_{48}\text{Cd} + _____$

[0.5 mark]

ii) $^{2}_{1}\text{H} + {}^{3}_{1}\text{H} \rightarrow _____ + {}^{1}_{0}n$

[0.5 mark]

QUESTION 4 (15 MARKS)

a) Define the following term:

i) Heat [1 mark]

ii) Radiation [1 mark]

iii) Latent heat [1 mark]

iv) Zeroth law of thermodynamics [1 mark]

v) Adiabatic changes [1 mark]

b) A nickel steel rod at 21 °C is 0.62406 m in length. Raising the temperature to 31 °C produces an elongation of 121.6 μm. Find the coefficient of linear expansion.

[2 marks]

Continued...

c) Given that 4.0 g of steam at 100.0 °C condenses to water on a burn victim's skin and cools to 45.0 °C. It is known that the specific heat of water and human tissue are 4186 J/kg.K and 3500 J/kg.K, respectively and the latent heat of water is 2.256×10^6 J/kg.
If the skin was originally at 37.0 °C, calculate the tissue mass was involved in cooling the steam to water. [2 marks]

d) A 2.0 mol sample of an ideal gas undergoes thermodynamic process as shown in Figure Q4. From A to B, the gas expands at constant temperature and 9600 J of heat enters the gas. From B to C, the gas is compressed at constant pressure and 7500 J of heat leaves the gas.

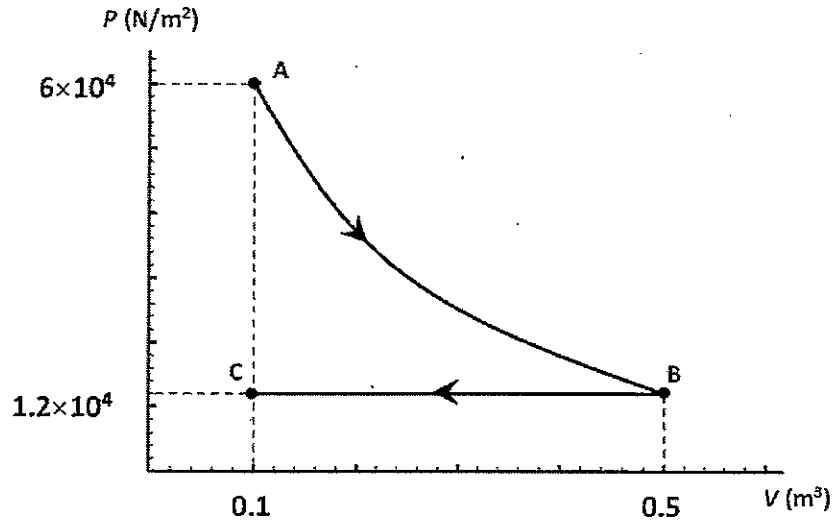


Figure Q4

(i) Name both process AB and process BC.

[2 marks]

(ii) Find the temperature of the gas in process AB.

[1 mark]

(iii) Using the first law of thermodynamics, determine the change in internal energy of the gas in process BC.

[3 marks]

End of paper.

APPENDIX

LIST OF PHYSICAL CONSTANTS

Electron mass,	m_e	=	9.11×10^{-31} kg
Proton mass,	m_p	=	1.67×10^{-27} kg
Neutron mass,	m_n	=	1.67×10^{-27} kg
Magnitude of the electron charge,	e	=	1.60×10^{-19} C
Universal gravitational constant,	G	=	6.67×10^{-11} N m^2 / kg^2
Universal gas constant,	R	=	8.314 J/mol K
Hydrogen ground state,	E_0	=	13.6 eV
Boltzmann's constant,	k_B	=	1.38×10^{-23} J/K
Compton wavelength,	λ_c	=	2.426×10^{-12} m
Planck's constant,	h	=	6.63×10^{-34} J s
		=	4.14×10^{-15} eV s
Speed of light in vacuum,	c	=	3.00×10^8 m/s
Rydberg constant,	R_H	=	1.097×10^7 m^{-1}
Acceleration due to gravity of earth,	g	=	9.80 m/s^2
1unified atomic mass unit,	1 u	=	931.5 MeV/c^2
		=	1.66×10^{-27} kg
1 electron volt,	1 eV	=	1.60×10^{-19} J
Avogadro's number,	N_A	=	6.02×10^{23} mol^{-1}
Threshold of intensity of hearing,	I_0	=	1.0×10^{-12} W/m^2
Coulomb constant,	$k = \frac{1}{4\pi\varepsilon_0}$	=	9.0×10^9 N m^2 /C^2
Permittivity of free space,	ε_0	=	8.85×10^{-12} C^2/N m^2
Permeability of free space,	μ_0	=	$4\pi \times 10^{-7}$ T m/A
1 atmosphere pressure,	1 atm	=	1.013×10^5 N/m^2
		=	1.013×10^5 Pa
Wien's displacement constant		=	2.90×10^{-3} mK
Speed of sound in air		=	343 m/s
Refractive index of air/vacuum	n	=	1.0
Earth: Mass,	M_E	=	5.97×10^{24} kg
Radius (mean),	R_E	=	6.38×10^3 km
Moon: Mass,	M_M	=	7.35×10^{22} kg
Radius (mean),	R_M	=	1.74×10^3 km
Sun: Mass,	M_S	=	1.99×10^{30} kg
Radius (mean),	R_S	=	6.96×10^5 km
Earth-Sun distance (mean),		=	149.6×10^6 km
Earth-Moon distance (mean),		=	384×10^3 km
First Bohr Raduis,	a_o	=	0.053 nm

LIST OF FORMULAS

$$\sin\theta_1 + \sin\theta_2 = 2\sin\left(\frac{\theta_1+\theta_2}{2}\right)\cos\left(\frac{\theta_1-\theta_2}{2}\right)$$

$$\cos\theta_1 + \cos\theta_2 = 2\cos\left(\frac{\theta_1+\theta_2}{2}\right)\cos\left(\frac{\theta_1-\theta_2}{2}\right)$$

$$\sin\left(\theta+\frac{\pi}{2}\right) = \cos\theta$$

$\sin\theta \approx \tan\theta \approx \theta$ *rad* for small angles

$D(x, t) = D_M \sin(kx \pm \omega t \pm \phi)$

$$v = \sqrt{\frac{F_T}{\mu}} \qquad v = \sqrt{\frac{\text{elastic property of the medium}}{\text{inertia property of the medium}}} \qquad v = (331 + 0.60T) \qquad v = f\lambda$$

$$f_n = \frac{nv}{2L} \qquad f_n = \frac{nv}{4L} \qquad \lambda_n = \frac{2}{n}L \qquad f' = f\left(\frac{v \pm v_o}{v \mp v_s}\right)$$

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad \frac{1}{f} = (n-1)\left\{\frac{1}{R_1} + \frac{1}{R_2}\right\} \qquad f = \frac{R}{2}$$

$$d\sin\theta = m\lambda \qquad d\sin(\theta) = \left(m+\frac{1}{2}\right)\lambda \qquad a\sin(\theta) = n\lambda$$

$$\lambda_m T = 0.2898 \times 10^{-2} \qquad I(\lambda, T) = \frac{2\pi c k_B T}{\lambda^4}$$

$$E_n = -\frac{mk^2e^4}{2\hbar^2}\left(\frac{1}{n^2}\right) \qquad r_n = \frac{\hbar^2}{mke^2}n^2 \qquad L = mvr_n = n\hbar$$

$$\frac{1}{\lambda} = R_H\left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right] \qquad \frac{1}{\lambda} = \frac{mk^2Z^2e^4}{4\pi c\hbar^3}\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right] \qquad \lambda = \frac{h}{p}$$

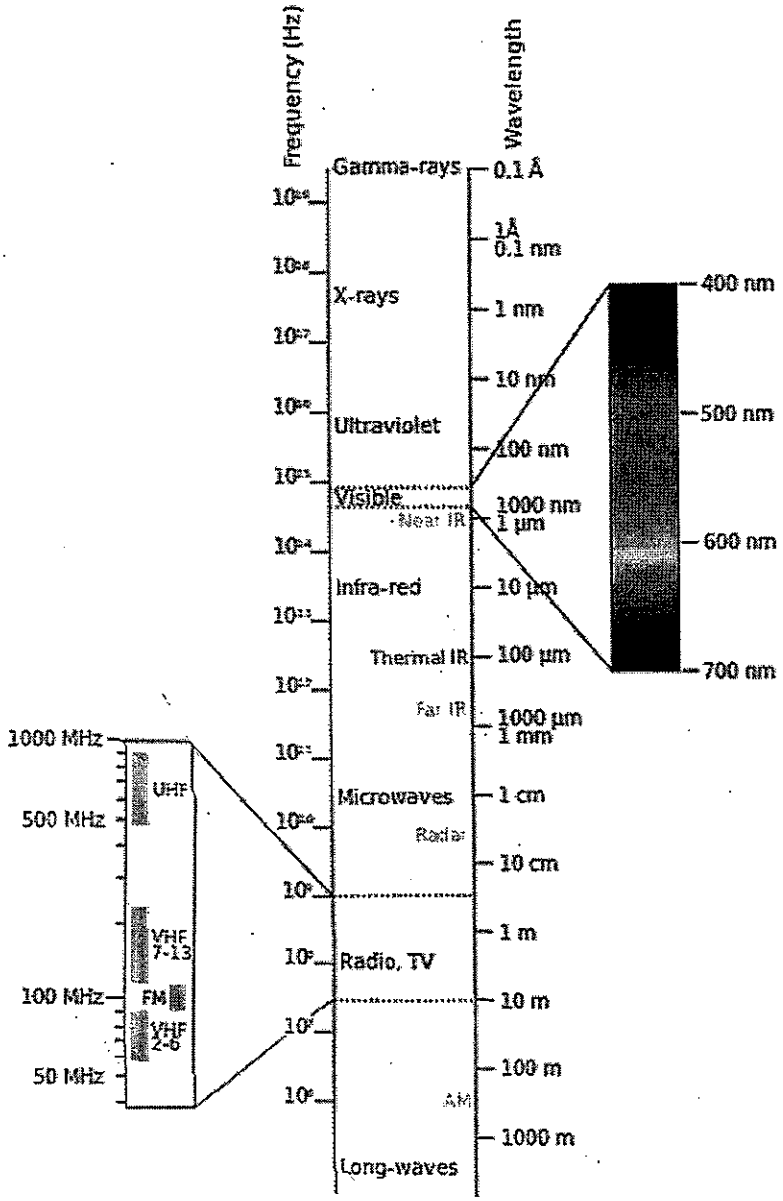
$$R = R_0e^{-\lambda t} \qquad \lambda = \frac{\ln 2}{T_{1/2}} \qquad Q = (M_X - M_Y - M_a)c^2$$

$$pV = nRT \qquad k = \frac{R}{N_A} \qquad N = N_0e^{-\lambda t}$$

$$\frac{\Delta Q}{\Delta t} = -kA\frac{\Delta T}{\Delta L} \qquad \frac{\Delta Q}{\Delta t} = e\sigma AT^4 \qquad \frac{\Delta Q}{\Delta t} = IeA\cos(\theta)$$

$$\overline{KE} = \frac{1}{2}m\bar{v}^2 = \frac{3}{2}kT \qquad U = \frac{3}{2}nRT$$

$$Q = \Delta U + W \qquad W = \int dW = \int_{V_i}^{V_f} PdV \qquad W = P\Delta V$$


Frequency (Hz)
Wavelength
Gamma-rays
X-rays
Ultraviolet
Visible
Near IR
Infra-red
Thermal IR
Far IR
Microwaves
Radar
Radio, TV
AM
Long-waves
0.1 Å
1 Å
0.1 nm
1 nm
10 nm
100 nm
1000 nm
1 µm
10 µm
100 µm
1000 µm
1 mm
1 cm
10 cm
1 m
10 m
100 m
1000 m
400 nm
500 nm
600 nm
700 nm
1000 MHz
500 MHz
100 MHz
50 MHz
UHF
VHF 7-13
FM
VHF 2-6